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Title: Tracking Charge and Energy Flow at the Nanoscale by Ultrafast Microscopy

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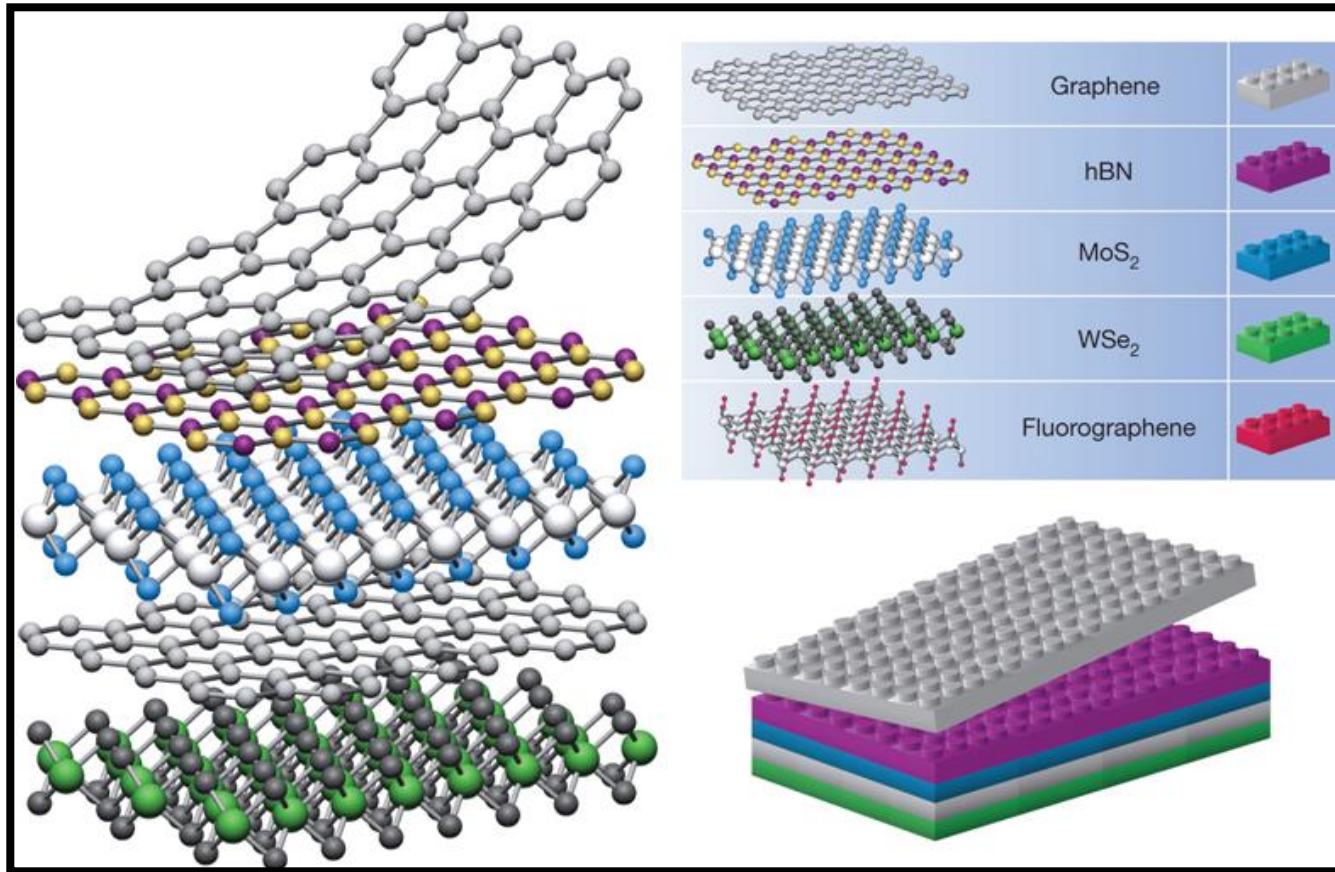
# Tracking Charge and Energy Flow at the Nanoscale by Ultrafast Microscopy

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Los Alamos National Lab

2021.11.19

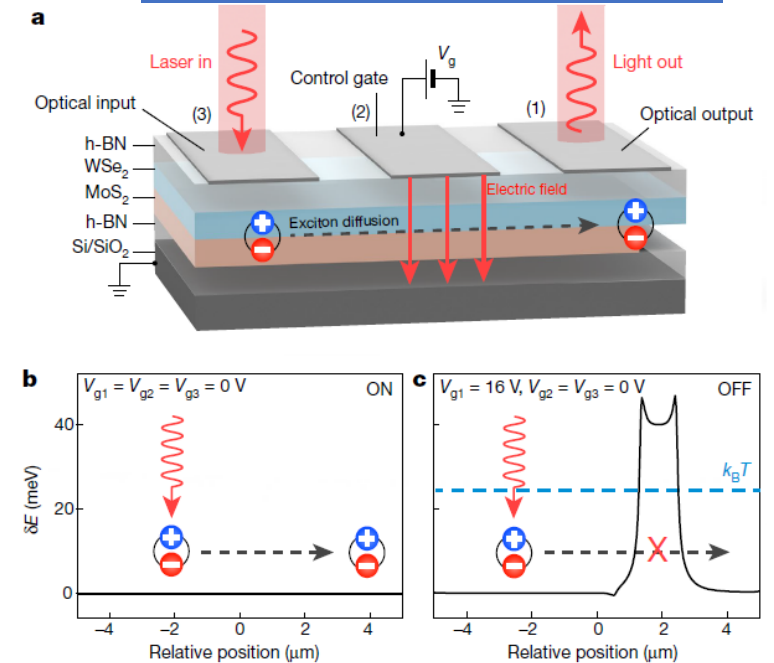
# Research Background



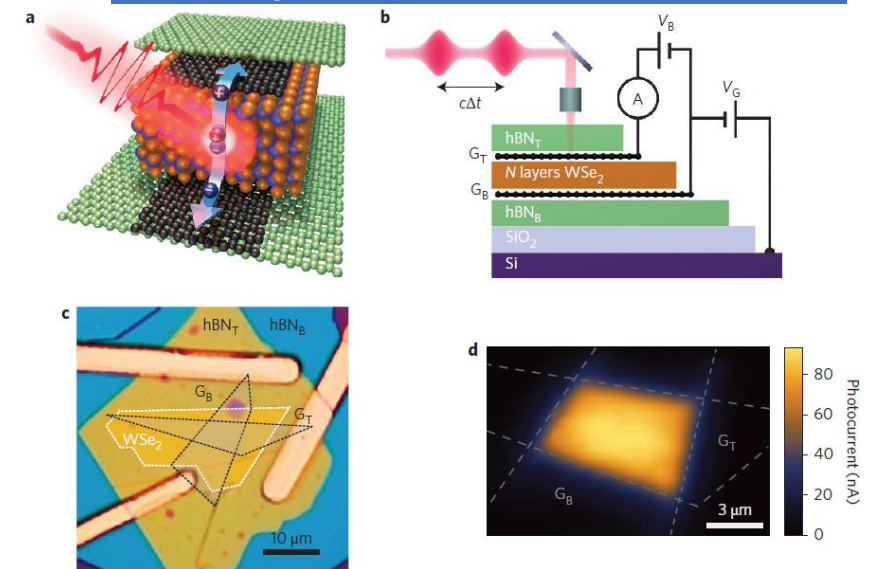
- Two-dimensional (2D) heterostructures can be formed by artificially stacking layers of different 2D materials
- 2D heterostructure optoelectronic devices with low-power consumption

A. K. Geim et al., *Nature* 499, 419 (2013)  
 Unuchek et al., *Nature* 560, 340 (2018)  
 Massicotte et al., *Nat. Nano* 11, 42 (2016)

## Excitonic Transistors

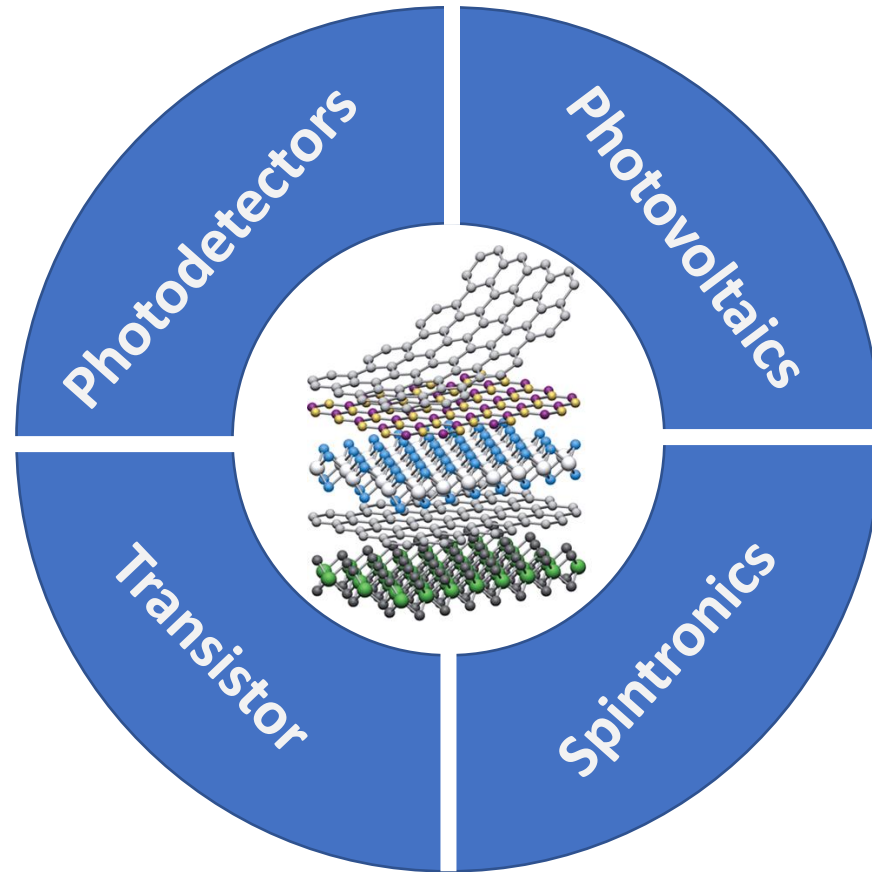


## Ultrafast Photodetectors

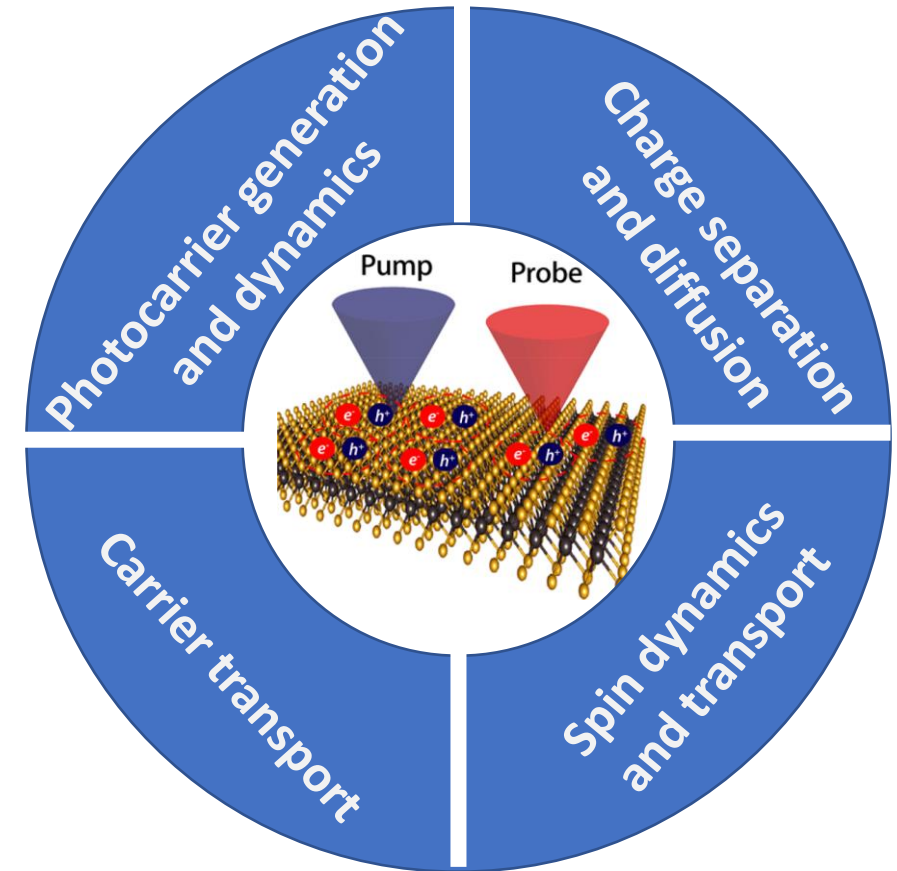


# Research Interests

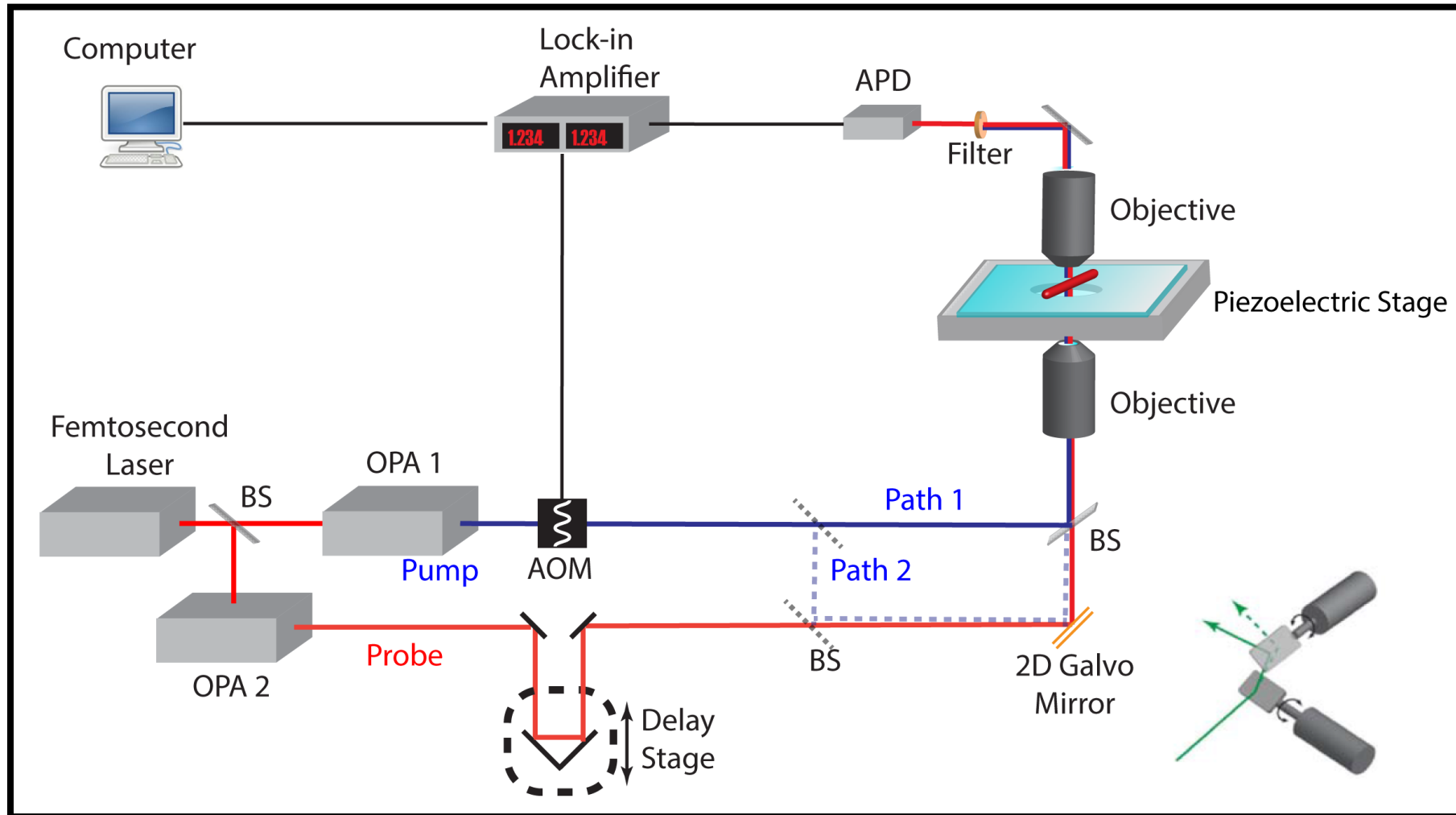
## *Macroscopic Device Performance*



## *Microscopic Photophysical Mechanism*



## Ultrafast Transient Absorption Microscope

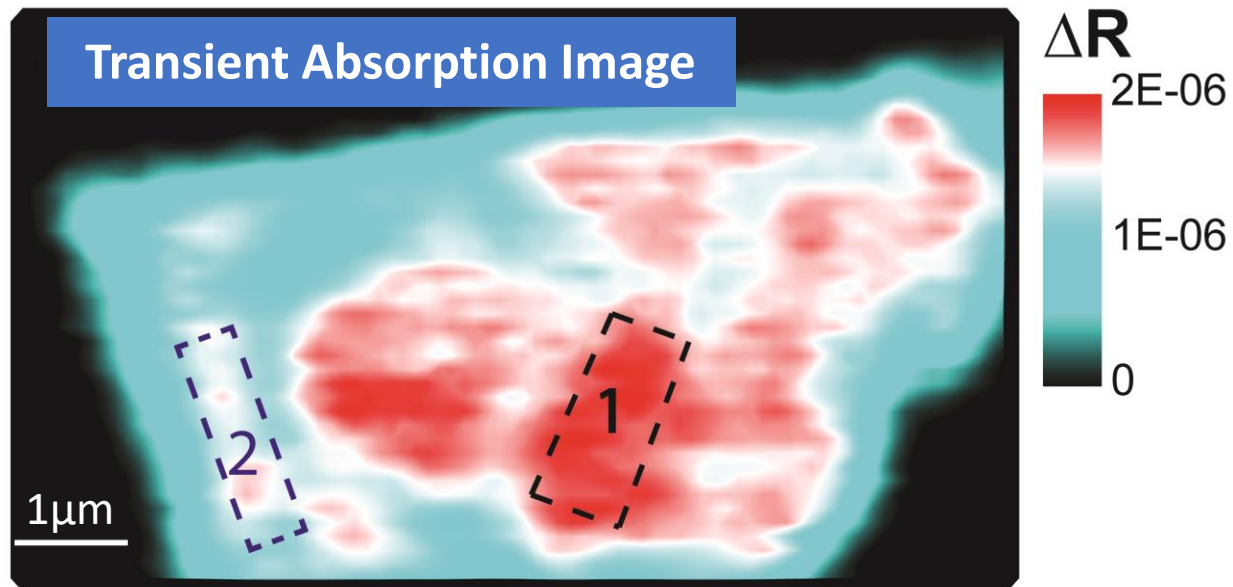
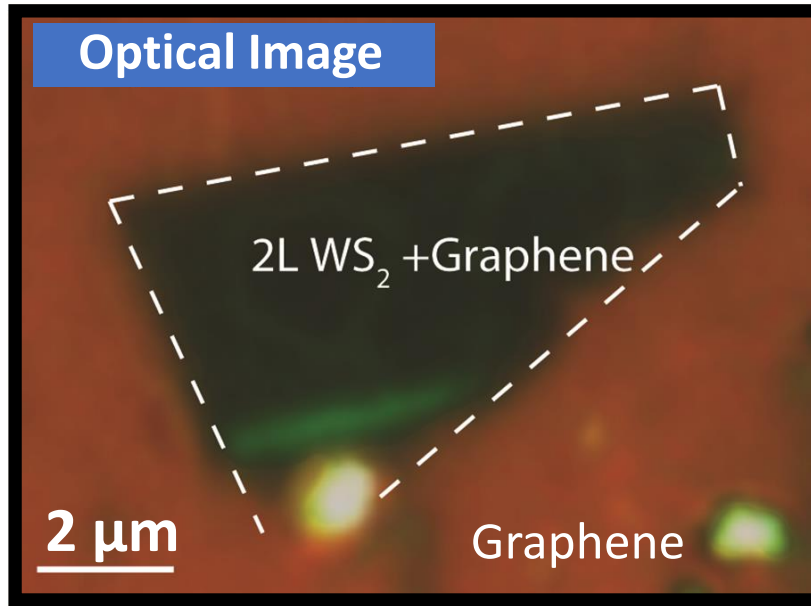


- *High temporal ( $\sim 200$  fs) and spatial precision ( $\sim 50$  nm) allows to directly track charge and energy flow at the nanoscale*

Note: PhD work at Purdue



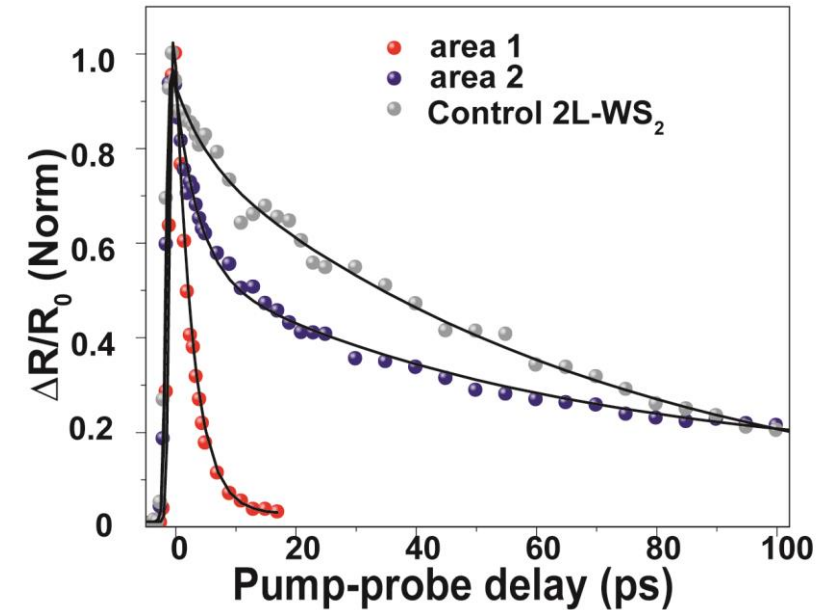
# Ultrafast Charge Transfer in WSe<sub>2</sub>-Graphene



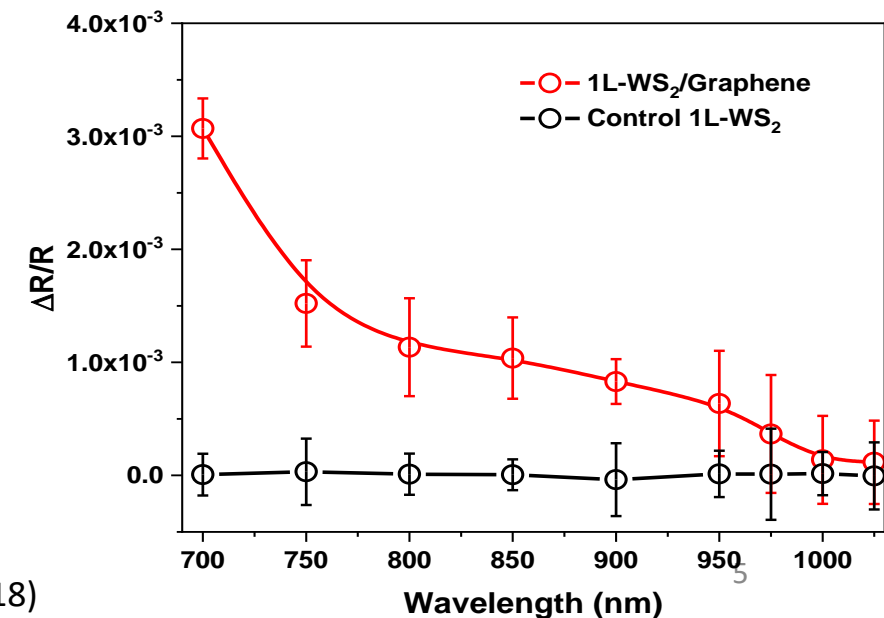
Note: PhD work at Purdue

L. Yuan et al., *Sci. Adv.* 4, e1700324 (2018)

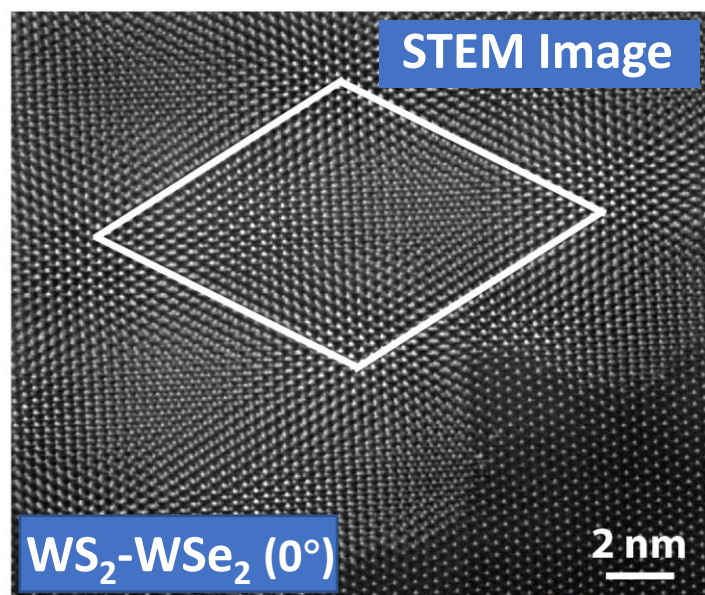
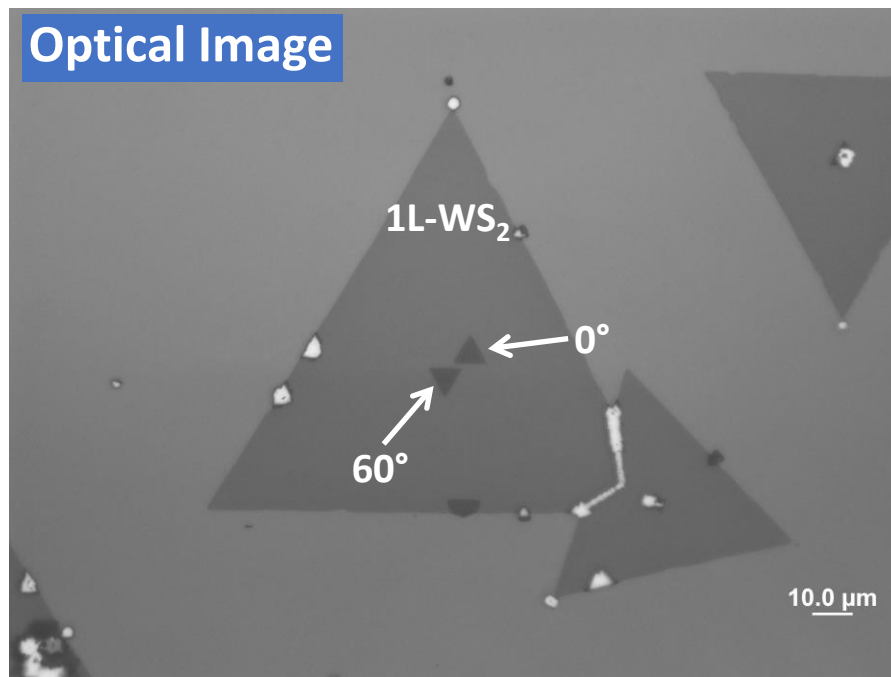
## Charge Transfer Dynamics



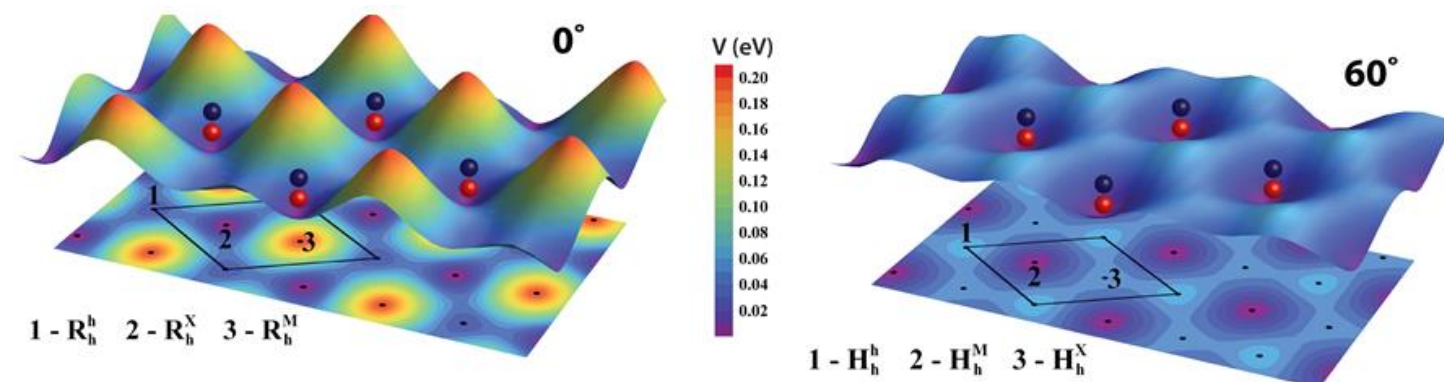
## Enhanced Photo-Carrier Generation



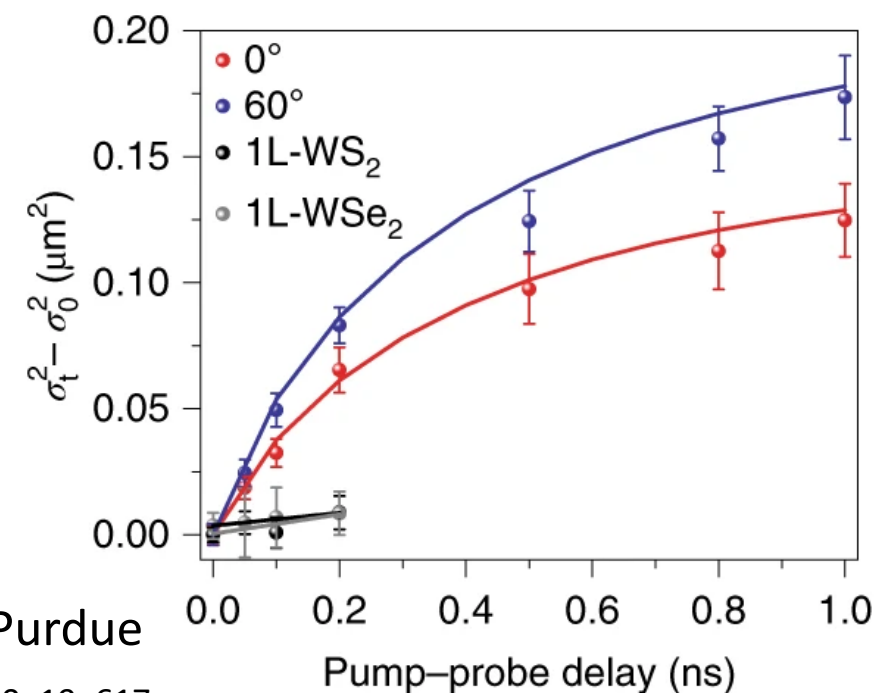
# Interlayer Exciton Transport in WS<sub>2</sub>-WSe<sub>2</sub>



## Twist-Angle-Dependent Moire Potential



## Twist-Angle-Dependent Interlayer Exciton Diffusion



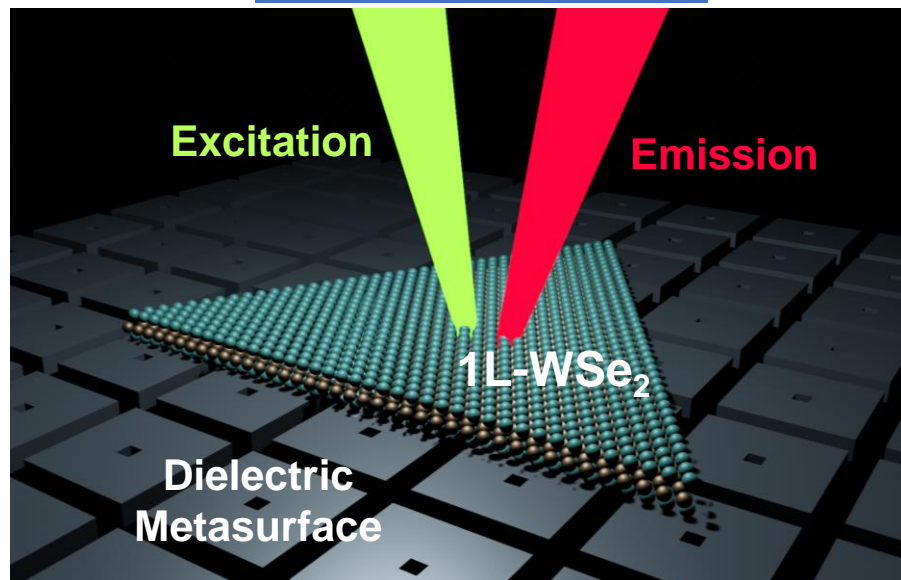
Note: PhD work at Purdue

L. Yuan et al. *Nat. Mater.* 2020, 19, 617

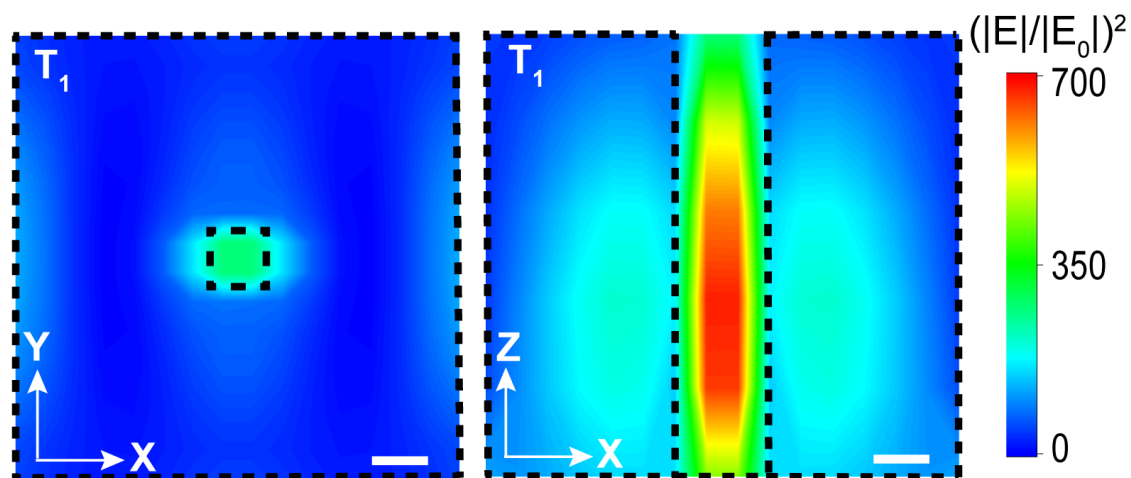


# Manipulation of Exciton Dynamics in WSe<sub>2</sub>/Metasurface

## WSe<sub>2</sub>-Metasurface



## Electric-Field Enhancement

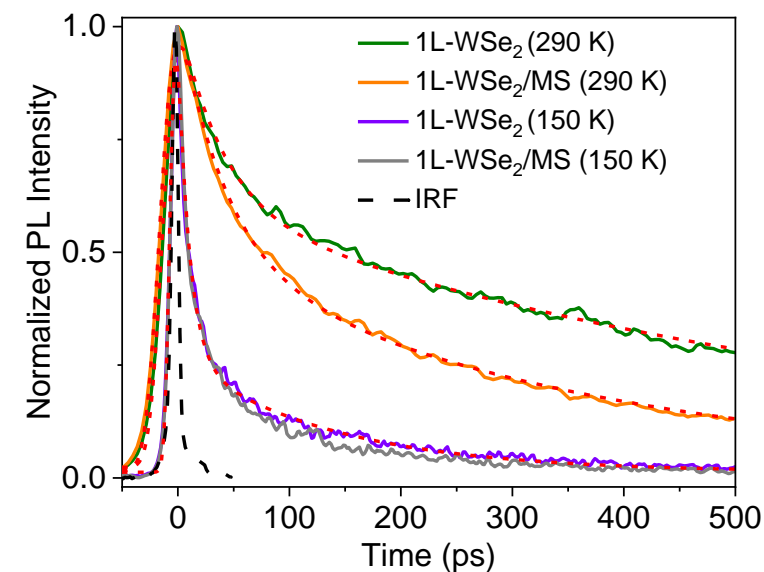
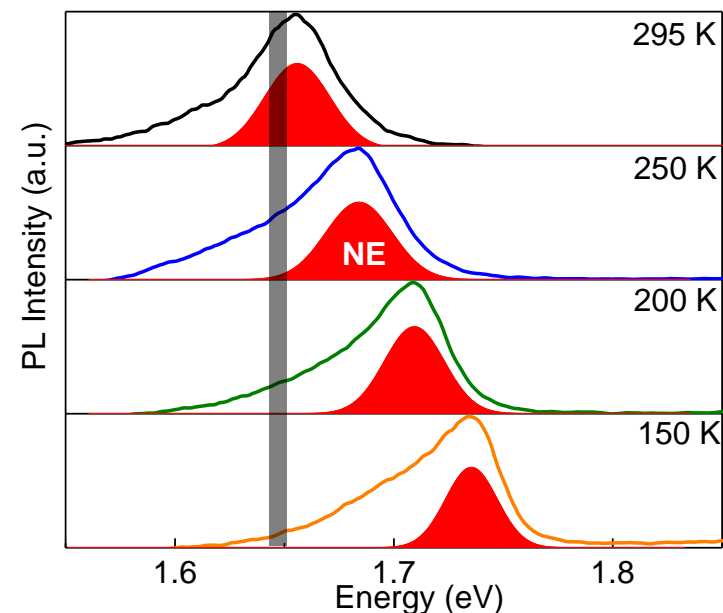


Note: Postdoc work at CINT

L. Yuan et al. *Nano. Lett.* 2021, In Press

## Manipulation of Exciton Dynamics

### MS Resonance



# Future Study

- **Investigate charge carriers dynamics and transport in emerging low-dimensional materials**
- **Develop novel nanophotonics platforms to enhance light-matter interactions in two-dimensional materials**